Space Weather Technical Forecast

Issued on Saturday 28 December 2024 at 01:24 Local

This technical forecast provides a four-day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

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Space Weather Forecast Headline: R1/R2 Likely throughout.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity at GOES16 has been Moderate, with two isolated M-flares and occasional upper-tier C-class flares observed, with a peak flare of M3.3 at 27/2035 UTC from AR3938 in the northeast. The other main sources of flare activity over the past 24 hours are AR3936 in the north-centre, and new or returning regions approaching the solar equatorial eastern horizon.

There are approximately 13 sunspot regions on the visible disc. Of these, 5 regions are of significance with either Zurich D- or E-group classification. AR3936 (Ekc/Beta-Delta), near centre disc in the northern hemisphere, is the largest region and one of the more complex, maintaining compact configuration and the presence of one or more faint delta regions.

AR3932 (Dai/Beta-Delta) near south-centre disc appears to contain a small delta spot at the western edge of the trailing group. AR3933 (Eso/Beta) in the southwest has decreased slightly in overall penumbral area and no longer displays evidence of a delta spot. show another possible weak delta spot. AR3928 (Dsi/Beta-Delta) has shown a spreading and consolidating tendency as well as the emergence of a faint and marginal delta region in the trailing group. The final sunspot region of note is AR3938 (Dsc/Beta-Gamma) in the northeast, which shows a north-south configuration of some of the spots within the region and appears dynamic with the emergence and fading of spots within the group as a whole. This region has been responsible for a number of flares during the period, including the peak M3.3 flare at 27/2035 UTC.

The current southern hemisphere far side is proving a fertile breeding ground for CMEs, with a good many observed over the past 3-days, most of which heading south, and later southeast from the far side, implying the presence of a large and active region here - potentially of note into the New Year period.

No Earth-directed CMEs have been observed leaving the solar disc in the past 24 hours. Although a number of filament eruptions or disruptions were observed on GONG H-alpha imagery none appear to have produced CMEs of note.

Solar Wind / Geomagnetic Activity: Solar winds, as observed at L1 by ACE and DSCOVR showed a slow regime, with background solar wind speeds falling from 360 km/s to current speeds of around 290km/s. The solar wind density has remained in single figures ppcc throughout. Although

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initially at average levels, density, fell to below average around 27/0400 UTC where it has since largely remained. The Interplanetary Magnetic Field (IMF) was weak throughout. The north-south component remained weak but erratic, fluctuating between +/-4nT. The phi angle was mostly negative (towards the Sun). The net result of the above solar wind measures was Quiet geomagnetic activity throughout (Kp 0-2).

Energetic Particles / Solar Radiation: High energy proton flux (greater than 10MeV) at GOES18 showed a continuing gradual decline below 1pfu, well below the S1/Minor Radiation Storm threshold.

High energy electron flux (greater than 2MeV) at GOES16 was at Moderate levels, peaking at 27/1700 UTC at 969pfu. The associated 24-hour fluence was below the Active (1e8 integrated flux) threshold on a slightly declining trend. The 28/0001UTC observation was 2.8e7 integrated pfu.

Four-Day Space Weather Forecast Summary

Solar Activity: Occasional M-class flares are Likely, with a Slight Chance of isolated X-class flares throughout. The arrival of one or more significant active regions across the eastern horizon Days 2-4 (29-31 Dec) increases the risk of more frequent and significant flare activity.

Solar Wind / Geomagnetic Activity: No coronal hole fast winds nor CMEs currently feature in the forecast. Any coronal holes on the disc are not expected to have any influence on wind speeds nor geomagnetic activity. Confidence remains low in the possibility of any glancing blows from CMEs during the period due to the weight of numbers of recent CME events across the whole Sun.

Geomagnetic activity is expected to be mainly Quiet (Kp 0-2), but with a Slight Chance of Active (Kp 4) intervals should any glancing CME effects occur - perhaps more probable on Days 1-2 (28-29 Dec).

Energetic Particles / Solar Radiation: There is a Slight Chance of S1/Minor Radiation Storm or greater enhancements during the period, this risk slightly increases later in the period as the larger groups rotate into a more favourable position.

Electron flux levels remain Moderate but are expected to gradually ease into the period in the absence of any enhancement. There remains a Slight Chance of exceeding Active Fluence levels at the start of the period, but this risk reduces by Day 2.

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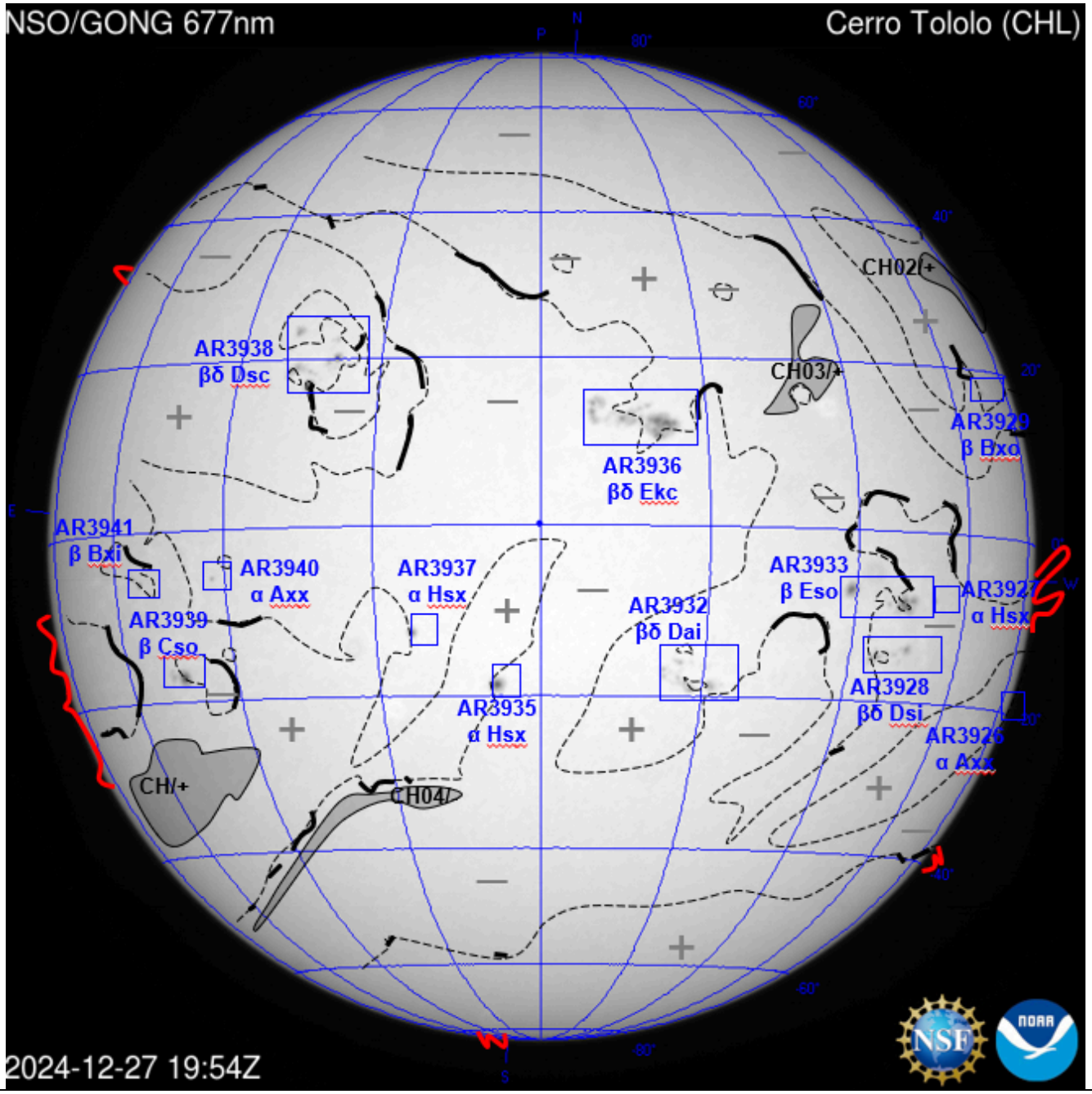
Figure 1: Solar Synoptic map valid 27/2000 UTC



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms

No CMEs are expected to arrive at Earth during the period, and no coronal hole fast winds are expected during the forecast period.

As stated in the solar analysis section, there have been numerous CMEs in recent days, some of these have been analysed close to the Earth-Sun line and may present the risk of minor glancing enhancement during Days 1-2 (28-29 Dec). Geomagnetic activity is expected to remain Quiet (Kp 0-2), although these glancing blows may produce isolated Active intervals (Kp 4). This is considered low confidence and low probability.

Solar winds are at background levels where they are expected to remain. A rise to Slightly Elevated levels is possible should any CMEs pass close to the Earth. MOSWOC Enlil output persists in showing a HSS from an uncertain source at the start of this period, but this is viewed as erroneous.

Geomagnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	**G1 to G2**	No	5	5	1	1
Strong	**G3**	No	1	1	1	1
Severe	**G4**	No	1	1	1	1
Extreme	**G5**	No	1	1	1	1

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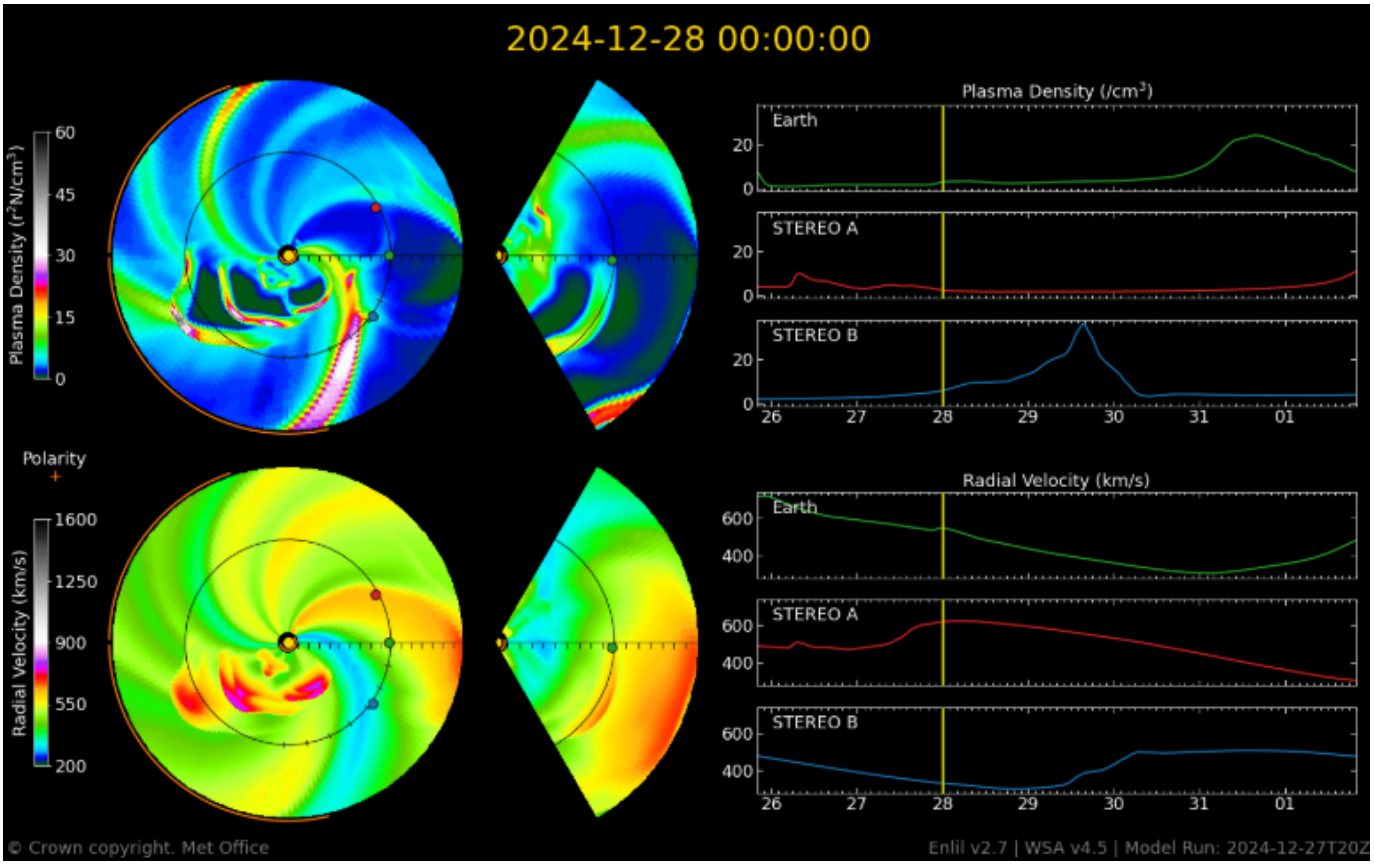
Figure 2: MOSWOC Enlil. Wind speeds are considered erroneous and poor guidance with background winds more probable throughout the period.



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Radio Blackouts - X-Ray Flares

The Penticton 10.7cm flux has been on a rising trend in recent days as the number of larger sunspot regions has increased, reaching a peak for this rotation. Values showing sign of some stabilisation.

Recurrence suggests the potential for further sunspot regions to round the eastern limb Days 2-4 (29-31 Dec), with this supported by recent far-side CME activity. Although far-side sounding output is not showing any significant regions (likely due to their proximity to the limb where soundings have a minimum ability to detect such regions) limb flux looping and coronagraph imagery suggests the presence of regions approaching the limb. None of the five sunspot regions of note are expected to rotate off of the disc in the four-day forecast period.

The assessment of any new regions notwithstanding, flare risk looks to remain elevated during the period and occasional M-class flares remain Likely, with a Slight Chance of X-class flares maintained throughout, pending further developments. The risk is considered to increase slightly later in the period based on the consideration of the aforementioned new or returning regions.

X-Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 (M Class)	No	70	70	70	80
Very Active	R3-R5 (X Class)	No	10	10	10	15

Figure 3: Latest GOES16 and GOES18 X-ray irradiance trace.

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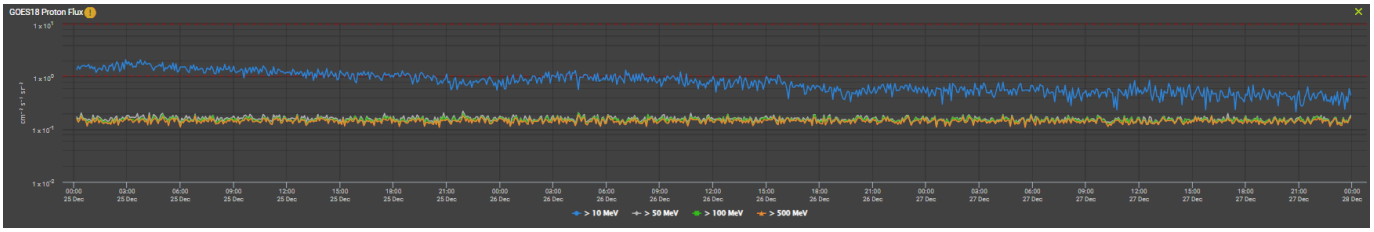
Solar Radiation Storms (High Energy Protons)

High energy proton counts have declined to background values. There remains a Slight Chance of S1/Minor Solar Radiation storms or greater should any significant flares occur from the larger regions on the disc as they rotate into more favourable locations for connection with Earth. The most likely enhancement initially would perhaps be a similarly slow and damped rise tied to any notable far-sided activity, although the large region responsible for the spate of recent far-sided CMEs is expected to near the least-well connecting part of the Sun during Day 1 (28 Dec).

Radiation Storms Probability (Exceedance)	Level ($cm^{-2}sr^{-1}s^{-1}$)	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	10	10	15	15
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and/or 50 MeV ≥ 10pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

Figure 4: 3-day (25/0000UTC-27/2359UTC) trace of GOES18 proton flux showing gradual decline in recent days.



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High Energy Electrons (≥ 2MeV)

Current high energy electron flux has been at Moderate levels in the last 24 hours. A steady state diurnal oscillation is expected through the period with a slightly declining trend. With no further drivers to increase electron populations, fluence will now most likely remain below Active throughout. MOSWOC REFM is now showing a steady forecast through the next three days, which is considered good guidance.

GEO Electron Environment	Level ($cm^{-2}sr^{-1}$ day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	≥ 2 MeV ≥ 1×10^{8}	No	5	5	5	5
Very Active	≥ 2 MeV ≥ 1×10^{9}	No	1	1	1	1

Figure 5: MOSWOC REFM showing general agreement in trend, although values slightly elevated compared to model expectations.

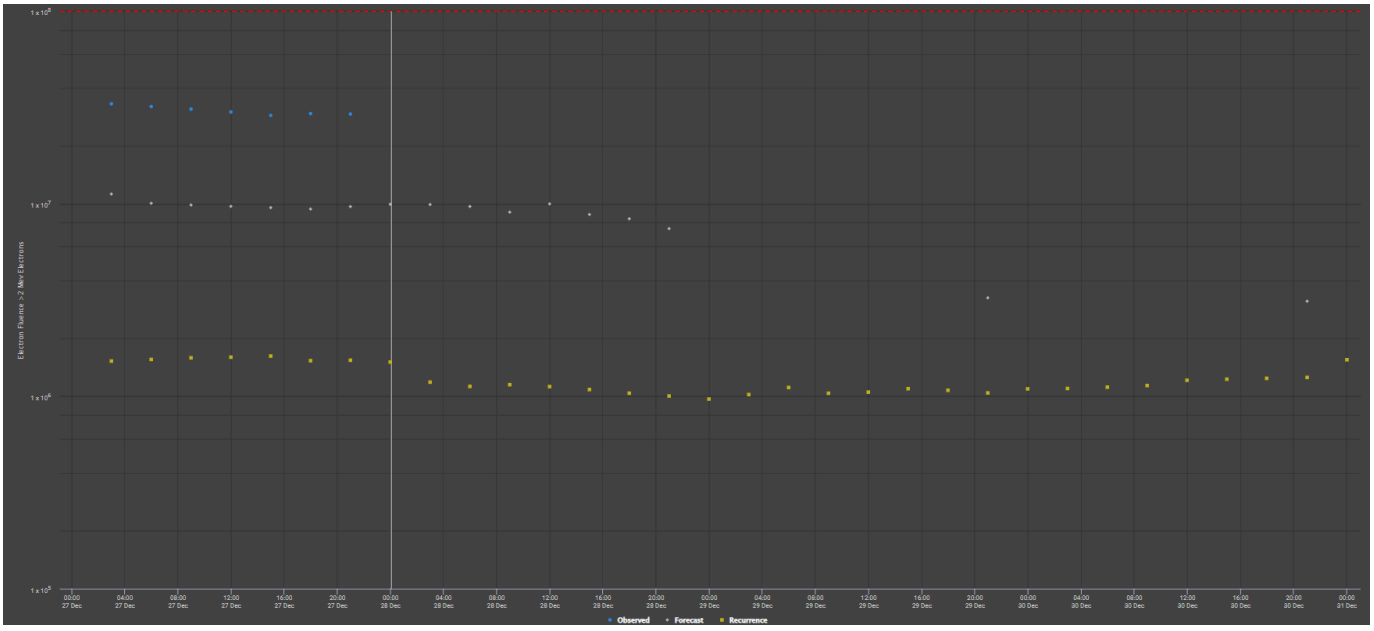

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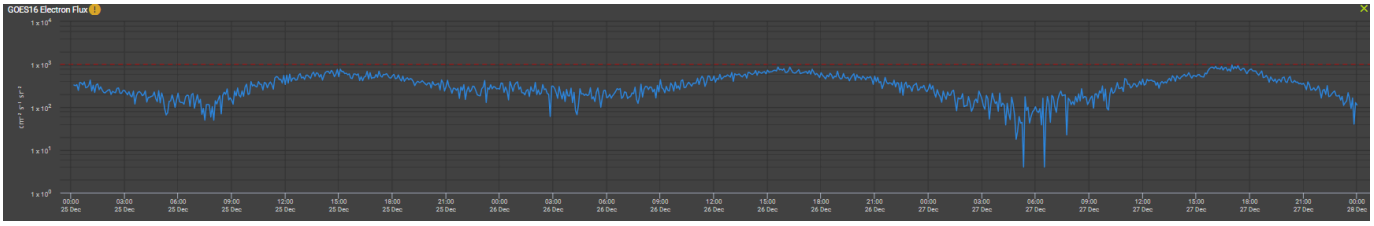
Figure 6: 3-Day GOES16 Electron flux trace (25/0000UTC-27/2359UTC) showing diurnal peak close to high levels.



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